Automatic Transfer Switch Protection

Automatic transfer switches (ATSs) are a vital part of many life safety-related systems and mission critical systems where continuity of service is crucial. The NEC requires 600V or less ATSs to be “listed for emergency system use” for emergency power systems [700.5(C)], legally required standby systems [701.5(C)], healthcare essential electrical systems [517.26], and critical operation power systems [708.24(C)(1)]. When designing a power system and specifying a transfer switch, two important design considerations must be evaluated:

1. An ATS’s Withstand and Closing (Close On) Ratings (WCR), which is analogous to its Short Circuit Current Rating.
2. How the overcurrent protective device protecting the ATS affects system selective coordination.

Both are related to the overcurrent protective device selection. A misapplication of the relationship between a transfer switch and its overcurrent protective device (OCPD) can have a severe impact on the integrity of the system and to the overall project cost. In addition, the characteristics of the transfer switch overcurrent protective device can impact whether selective coordination can be achieved for the full range of overcurrents. This section focuses on ATS short-circuit current protection and the common misconceptions and deficiencies of non-current limiting protection. Please see the SPD section on selective coordination for more information concerning system overcurrent protective device coordination.

![Diagram of Overcurrent Protective Device](image)

**Figure 1**

**Automatic transfer switches must comply with the Withstand and Closing (Close On) Ratings (WCR)**

**Requirements of UL 1008 Transfer Switch Equipment.**

A clear understanding of the relationship between a transfer switch’s short-circuit current withstand and closing rating and its protective device is imperative to assure a well designed installation. See Figure 1. An ATS must be properly protected for short-circuit currents from either source of power or in the case of closed transition ATSs, the combination of the fault current from each source. If a transfer switch is subjected to a fault current above its maximum short-circuit current withstand and closing rating, severe ATS damage (including a potential fire hazard and arc flash hazard), and severe injury or death may result.

**Options for ATS Protection**

Transfer switches are tested, listed, and labeled for use with either fuses or circuit breakers; each offering different levels of protection. UL 1008 Transfer Switch Equipment is the product standard for transfer switches. Within this standard there are two ATS short-circuit current withstand tests. First the transfer switch must withstand a short-circuit when the switch is in a closed position. During the second withstand test the ATS must transfer, close and withstand the short-circuit current until the current is cleared. ATSs must pass both of these tests at the same available short-circuit current magnitude and survive within specified acceptable damage levels. The term commonly used in the industry for this ATS short-circuit current rating is WCR for Withstand and Closing (Close On) Rating.

**Circuit Breaker Protection Options for ATS WCR**

ATSs protected by circuit breakers can be classified by one of three different Withstand and Closing (Close On) ratings:

1. Specific circuit breaker rating
2. “Any Breaker” rating: 3 cycle short-circuit test rating applicable to any circuit breakers having an instantaneous trip
3. Short time rating (may be rated for 18-30 cycles)

These three ATS short-circuit protection options for circuit breaker are indicated in Figures 2 and 3 by the corresponding number (1), (2), or (3).

**1. Specific Breaker WCR Rating**

For a transfer switch to receive a “specific breaker” rating in accordance with UL 1008, it must be short-circuit current tested when protected by a specific circuit breaker (CB manufacturer, type designation, and ampere rating). ATS manufacturers typically will provide many specific circuit breaker choices that have been tested and listed for a particular transfer switch. ATS manufacturers provide documentation of these acceptable “specific breakers”. See Figure 2 option 1 for label example. Figure 3, Specific Breaker Rating column marked (1), provides the levels of protection, in amperes, achievable through the use of specific breakers for a particular transfer switch series. To view the list of specific breakers tested and accepted, it is necessary to contact the ATS manufacturer.

Certain issues may arise when specific breaker combinations are used. Specific breaker ratings are usually a hindrance on bid day, because in most circumstances, the vendor providing the circuit breaker and the transfer switch are not the same. This places extra responsibility on the contractor and consulting engineer to make sure the ATS/circuit breaker pair is a tested, listed combination. Specific breaker combinations are often highly scrutinized by the authority having jurisdiction during an inspection. Although a specific breaker may be properly short-circuit combination rated with the transfer switch at the time of the initial installation, it is very likely that over the life of a system the circuit breaker may need to be replaced. The person tasked with finding a replacement circuit breaker, may not fully understand the importance of the relationship between the circuit breaker and the ATS it is protecting. If a new circuit breaker is installed that differs in type and/or rating, it may not be listed to protect the transfer switch, and could be a potential hazard. Finally, if proper maintenance is not performed circuit breakers’ trip characteristics may change as they age. The tripping time may become slower, thus exposing the transfer switch to energy above the original short circuit test values. See the Reliability and Maintenance section in the SPD publication for more information.

**3 Cycle “Any Breaker” WCR Rating**

The 3 cycle rating was introduced into UL 1008 in 1989. It allowed ATS manufacturers to provide their switches with another rating category for short-circuit current WCR. An ATS that passes this test is able to withstand a fault of a given magnitude for 3 cycles (1.5 cycles for switches 400A and less and tested for 10,000A WCR.) and not exceed certain damage criteria. See Figure 2 option 2 for label example. See Figure 3 “Any” Breaker Rating column marked (2).

The purpose of the test is to allow a transfer switch to be marked for use with any manufacturer’s circuit breaker that incorporates an “instantaneous trip” when the transfer switch and circuit breaker are applied within their ratings. The umbrella ratings provided by this test allow an engineer more flexibility when specifying circuit breaker protection for a transfer switch. This option does not have many of the procurement, installation, or replacement issues incurred when using the specific breaker option (1). It was for this reason the rating was referred to as the “any breaker” rating and was considered the
best practice solution when using circuit breakers for ATS protection. This however has changed recently with the advancement and growing understanding of selective coordination; see circuit breaker option (3), which follows.

(3) Short time WCR Ratings with Circuit Breakers

New considerations for ATSs came to the forefront with the addition of selective coordination requirements for emergency systems, legally required standby systems and healthcare essential electrical systems into the 2005 NEC. (A similar requirement for critical operations power systems was included in the 2008 NEC.) See the selective coordination section in Cooper Bussmann SPD publication for more information.

Designers desiring selective coordination with circuit breakers often use circuit breakers with short time delay tripping (CB without instantaneous trip) in vital systems. Circuit breakers with short-time delay and no instantaneous trip increase the time that an ATS must withstand a short-circuit current. Since the short-time delay opening time will exceed the three cycle time limit for the 3 cycle “any breaker”, Option 2 of Figure 2 or Column 2 of Figure 3 cannot be utilized.

Because of the selective coordination requirements for the life-safety-related loads, the 3 cycle, “Any Breaker” ratings that were previously the norm for ATS protection in circuit breaker designs, are no longer sufficient in many cases. Practical example: If the circuit breaker upstream protecting a transfer switch has an intentional short time delay of 0.1 seconds (6 cycles), a 3 cycle “any breaker” rating will not provide adequate protection for the ATS.

In recent years some ATS manufacturers have introduced short time rated ATSs to aid in circuit breaker designs requiring selective coordination. The short time test subjects an ATS to a given fault current for up to 30 cycles, for which the ATS cannot sustain extensive damage and must be operable afterwards. The options available for transfer switches with short time ratings are very limited and also usually carry a much higher price tag when compared to similar standard ATSs of the same amp size. See Figure 2 option 3 for short-time WCR and see Figure 3, “Short-Time” column (3).

Fuse Protection Option for ATS WCR

(4) Fuse Protection Option for ATS WCR

The other option for ATS protection is the use of current limiting fuses. The current-limiting ability of fuses to limit let-through current and thereby reduce the damaging energy during a fault, assures the ATS will be protected even when exposed to very high fault levels; in almost all cases up to 200kA. (See the Fuseology section for a better understanding of how a fuse operates and is able to limit fault current.) Along with providing far superior protection, fuses are simple. The combination tested fuse class and maximum amp rating is given by ATS manufacturers along with the WCR protection level. See Figure 2, option 4 Fuse WCR, and Figure 3, ATS Protected by Current-Limiting Fuse Protection columns (4).

Simplicity in Achieving High WCRs

It is fast and easy to specify fuse protection and achieve high ATS WCR. In most cases, regardless of manufacturer, ATSs will have a 200kA WCR with current-limiting fuses. This simplicity is far different than the process of choosing the right circuit breaker for protection. Compare Tables 1 and 2 which outline some of the ATS characteristics that must be evaluated to adequately specify fuse or circuit breaker protection for ATS WCR. When choosing circuit breaker protection, an ATS’s WCR varies considerably based on the type circuit breaker used and the characteristics of the ATS; these considerations will have an impact on the design as well as the installation. When using fuse protection, the specifier, installer or facility owner does not have to be concerned with the specifics of the maximum available short-circuit current during the design/install process or whether the fault current may increase during the system life time, (because very few systems have available short-circuit currents above 200kA).

Table 1: What determines an ATS’s WCR when protected by fuses:

- Only the switch amp rating and the fuse UL class/max. amp rating (Almost all ATSs, regardless of manufacturer, have a WCR of 200,000A when protected by current-limiting fuses. There are very few exceptions.)

Table 2: What determines an ATS’s WCR when protected by a circuit breaker:

- ATS Manufacturer (ASCO, Russelectric, EATON, Kohler, etc.)
- ATS Series (i.e. 300, 4000, 7000)
- Voltage (240V, 480V, 600V)
- Frame size (amp rating)
- Bypass/Non-Bypass Switch
- # of poles (2, 3, 4)
- Type of neutral (solid, switched, overlapping)
- Connection type (front/rear connect, mechanical/compression lugs)
- Type circuit breaker to be used: specific manufacturer, any breaker without instantaneous trip, short-time delay without instantaneous trip (and for how long)

As you can see in Table 2, there are many factors that define the protection level provided by a circuit breaker. Following the ATS manufacturers’ WCR chart, (similar to Figure 3) a specifier or installer cannot be assured that in all applications a circuit breaker will provide adequate protection. Common configurations such as using a 4 pole overlapping neutral will actually result an ATS with a lower WCR rating in certain cases. For one major ATS manufacturer, an ATS from 260 to 600A has a 42kA, 3 cycle WCR rating at 480V when protected by any circuit breaker. However, if a 260 to 600A ATS with a 4 pole overlapping neutral is used, the rating would only be 35kA for these switches when protected by any circuit breaker. These same ATSs protected by appropriate fuses have a 200kA WCR.

Another commonly overlooked design concern is the connection type chosen for the ATS. Certain ATSs have optional front, rear, or side connect versions to help accommodate sizing concerns and aid in installation. For instance, an ATS when designed as a rear connect switch is rated for 65kA WCR with any circuit breaker protection, but may only have a 50kA WCR if the front connect version is chosen with any circuit breaker protection. Similarly when protected by a circuit breaker, the WCR for an ATS may vary with the type of cable connections specified. While in most cases the standard connection type for ATS installation is mechanical screw type lugs, many projects request compression lugs for ATSs. This will in most cases also adversely affect the WCR given to an ATS when protected by a circuit breaker. If these ATSs are protected by fuses, these ATS characteristics are a non-issue and the WCR is typically 200kA.

Practical Examples

Cost Factor Example 1

Along with the superior current limiting protection and simplicity that fuses provide there is in most cases, a substantial cost savings. Let’s take a look at a common automatic transfer switch example: The following pricing example has been taken from an actual transfer switch quote, and is a common occurrence across ATS manufacturers. The manufacturer name and parameters have been omitted.

Requirement

A consulting engineer needs to specify the following for a hospital patient wing addition. In their design circuit breakers will be used upstream to protect the ATSs.

- Qty (5) Automatic Transfer Breaker Isolation Switches, 600A, 480V, 4 pole switched neutral, with a NEMA 1 enclosure

Initial ATS Cost Estimate

From ATS manufacturer:

- The estimated cost per switch: $15,000.00
- Cost for Qty (5): $75,000.00
- Footprint dimensions per switch: 34"W x 28"D (Height not considered)

ATS Cost Modified due to Fault Current

However when the available fault current is calculated, it is determined that there is a 58kA RMS available short-circuit current at the ATS. The designer concludes that these transfer switches will require a 65kA 3 cycle, WCR. (This assumes instantaneous trip circuit breakers will be used.)

After reviewing the WCR chart provided by the ATS manufacturer (similar to Figure 3), the engineer discovers the transfer switch quoted above is only rated to withstand 42kA for 3 cycles. In order to assure the ATS can withstand a fault current of this magnitude it is necessary to move up to the next ATS frame size, and purchase an ATS with adequate WCR. The next frame size offered by this ATS manufacturer is their 800 to 1200A ATS. The engineer again goes back to the WCR chart and learns that a switch of this size is only rated for 50kA for 3 cycles. Again, this will require the move up to an even larger ATS. The next ATS frame size manufactured is 1600-2000A. After reviewing the WCR chart the consultant sees that these switches can withstand faults of 100kA depending on the required ATS characteristics. Either way, this switch will be able to withstand the 58kA available and meet the 65kA 3 cycle requirement. The consultant goes back to the ATS manufacturer for a new price.
This is a very common example. It may or may not be made clear during a bid or submittal review that these changes have occurred, but the added costs are real. These additional costs are in most cases figured in by the ATS manufacturer during the initial bid and never questioned. When using circuit breakers, there can be a substantial price premium incurred when the system has higher available short-circuit currents. The larger ATSs will also take up more floor space in already crowded electrical rooms.

**Automatic Transfer Switch Protection**

**ATS Cost with Fuse Protection**

Both of these situations could be avoided however with the use of fuses. If current limiting fuses are specified upstream of the ATS, the energy let through during a fault will be far below the withstand threshold of the ATS, allowing the original 600A ($15,000) transfer switches to be protected from any fault up to 200kA. With fuse protection, the original ATS cost estimate would be applicable. This in turn would have saved the end user over $100,000.00! In addition, floor space is conserved.

**Requote of ATS Cost Estimate**

From ATS manufacturer:

- The new cost per switch: $35,000.00
- Cost for Qty (5): $175,000.00
- Footprint dimensions per switch: 38"W x 60"D

Additional cost = $20K per ATS x Qty (5) = $100,000.00 to Owner

Additional floor space required = 20"W x 160"D in electrical room

This is a very common example. It may or may not be made clear during a bid or submittal review that these changes have occurred, but the added costs are real. These additional costs are in most cases figured in by the ATS manufacturer during the initial bid and never questioned. When using circuit breakers, there can be a substantial price premium incurred when the system has higher available short-circuit currents. The larger ATSs will also take up more floor space in already crowded electrical rooms.

**Practical Example 2**

The following is another real transfer switch example. This illustrates issues that may arise after initial design. A consulting engineer specifies an ATS protected by circuit breakers. The engineer calculates the available fault current as designed at the ATS to be 48kA and labels the drawings accordingly. After reviewing the drawings the contractor purchases an ATS with a WCR of 50kA. When installing the conduit and pulling the cables the contractor finds a shorter path to run the cabling to the ATS than originally planned and is able to save on conductor material and installation costs. The ATS is manufactured, shipped, and installed at the job site. When the "as installed" short circuit current for transfer switches with available fault current up to 200kA.

An inspector will not approve this ATS that is not rated for use with the maximum available fault current plus there is a liability if installed in this manner. If the contractor requests a return and purchase of a properly rated ATS from the manufacturer, there will surely be a change order and extra costs involved. Who pays? This is another real example that is common across the industry. The solution to this dilemma by some contractors is to run the cabling down a hallway and back again to reduce the available fault current to what was originally expected! Is that good practice? This again could be avoided with fuse protection. In most cases, fuses provide a simple, no worry solution for transfer switches with available fault current up to 200kA.

**Fuse Protection**

When protected by specified amp maximum Class fuse shown, this transfer switch is rated for use on a circuit capable of delivering not more than _rms symmetrical amps and at _volts maximum shown.
Automatic Transfer Switch Protection

This chart and notes provide an example of the information ATS manufacturers provide as a starting point for specifying overcurrent protection for their transfer switches. Fuses provide WCR protection typically up to fault currents of 200kA. Circuit breaker protection on the other hand typically results in lower ATS WCRs and there may be many exceptions to this chart. See the Simplicity in Achieving High WCRs section for more details.

**Notes:**

1. WCR with specific circuit breaker: with this option the ATS manufacturer will provide a list of specific circuit breakers detailing the circuit breaker manufacturer, CB type or series, max. voltage, max. amp rating, and ATS WCR rating with that specific CB. Contact ATS manufacturer.

2. WCR with “Any” circuit breaker: the circuit breakers for this option must have an instantaneous trip and clear within 3 cycles (1.5 cycle clearing for switches 400A and less and tested for 10,000A WCR). The circuit breaker ampere rating would be based on NEC® requirements.

<table>
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<th>Transfer Switch Amp Rating</th>
<th>ATS Specific Circuit Breaker WCR Note1</th>
<th>Max. Voltage</th>
<th>ATS Any Circuit Breaker WCR Note 2</th>
<th>Max. Voltage</th>
<th>ATS Short Time WCR (Circuit Breaker without instantaneous Trip)</th>
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